PATENT ABSTRACTS OF JAPAN

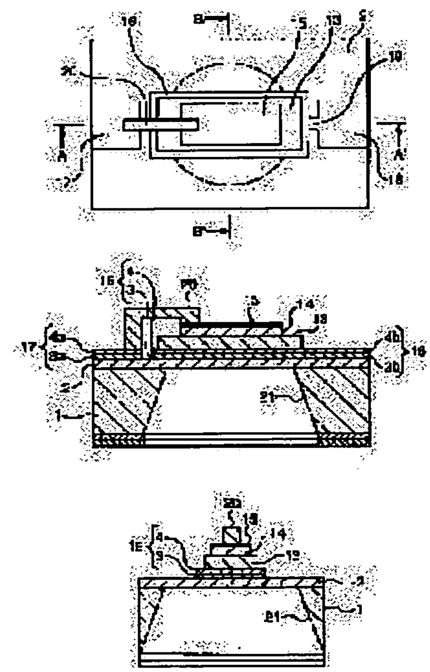
(11)Publication number : 11-284480
(43)Date of publication of application : 15.10.1999

(51)Int.Cl. H03H 9/17

(21)Application number : 10-081085
(22)Date of filing : 27.03.1998

(71)Applicant : MITSUBISHI ELECTRIC CORP
(72)Inventor : YAMADA AKIRA
MAEDA CHISAKO
UMEMURA TOSHIO
UCHIKAWA HIDEFUSA

(54) PIEZOELECTRIC THIN FILM RESONATOR



(57)Abstract:
PROBLEM TO BE SOLVED: To adjust simply a thin film element resonance frequency in a short time by providing a piezoelectric thin film made of a specified material and a dielectric thin film also made of a specified material between a pair of exciting electrodes, so as to build up a thin film element resonating at a frequency corresponding to a sum of the thickness of the piezoelectric thin film and the dielectric thin film.
SOLUTION: A piezoelectric thin film element is made by providing a piezoelectric thin film 13 and a dielectric thin film 14 between a lower electrode 16 and an upper electrode 15, via an insulation film 2 on a substrate 1 having an opening 21. A sound wave propagates through a composite layer, consisting of the piezoelectric thin film 13 and the dielectric thin film 14 in the thickness direction and causes a resonance in that direction. the piezoelectric thin film 13 is made of a composite oxide material such as lead titanate. Since the piezoelectric constant of the piezoelectric thin film 13 can be managed with comparatively high accuracy, the sum of the thickness of the piezoelectric thin film 13 and that of the dielectric thin film 14 is managed with high accuracy within a prescribed range, and the accuracy of the resonance frequency is improved. The dielectric thin film 14 is made of an oxide material such as magnesium oxide.

LEGAL STATUS
[Date of request for examination]
[Date of sending the examiner's decision of rejection]
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]
[Date of final disposal for application]
[Patent number]

[Date of registration]
[Number of appeal against examiner's decision of rejection]
[Date of requesting appeal against examiner's decision of rejection]
[Date of extinction of right]

(19)日本国特許庁(JP)　(12)公開特許公報（A）　(11)特許出願公開番号

特開平11－284480

(43)公開日　平成11年(1999)10月15日

(51)Int. Cl.⁶	識別記号	F I		
H03H　9/17		H03H	9/17	F

審査請求　未請求　請求項の数9　OL　（全9頁）

(21)出願番号　特願平10-81085

(22)出願日　平成10年(1998)3月27日

(71)出願人　000006013
三菱電機株式会社
東京都千代田区丸の内二丁目2番3号

(72)発明者　山田　朗
東京都千代田区丸の内二丁目2番3号　三菱電機株式会社内

(72)発明者　前田　智佐子
東京都千代田区丸の内二丁目2番3号　三菱電機株式会社内

(72)発明者　梅村　敏夫
東京都千代田区丸の内二丁目2番3号　三菱電機株式会社内

(74)代理人　弁理士　青山　葆　（外1名）

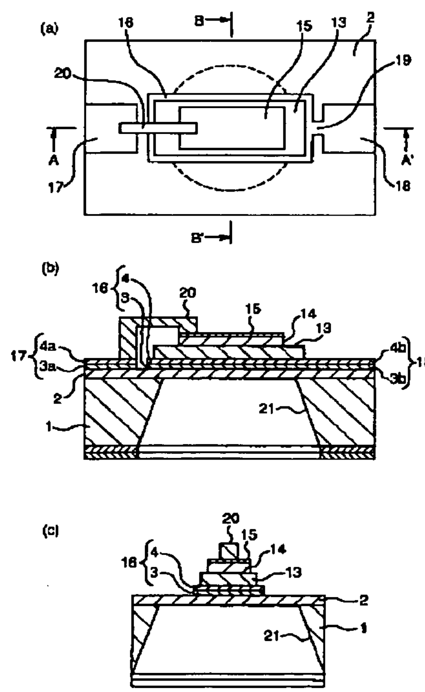
最終頁に続く

(54)【発明の名称】圧電薄膜振動子

(57)【要約】

【課題】　短い時間でかつ簡便に周波数調整することができる構造を有し、安価に製造できる圧電薄膜素子を提供する。

【解決手段】　一対の励振用電極の間に圧電体薄膜を備えた圧電薄膜振動子において、一対の励振用電極の間にさらに第1誘電体薄膜を設け、圧電体薄膜の厚さと第1誘電体薄膜の厚さとを合わせた厚さに対応した周波数で共振させた。



【特許請求の範囲】

【請求項１】　一対の励振用電極の間に圧電体薄膜を備えた圧電薄膜振動子において、
上記一対の励振用電極の間にさらに第１誘電体薄膜を設け、上記圧電体薄膜の厚さと上記第１誘電体薄膜の厚さとを合わせた厚さに対応した周波数で共振させたことを特徴とする圧電薄膜振動子。

【請求項２】　上記圧電薄膜振動子において、上記一対の励振用電極のうち上部に位置する励振用電極上に第２誘電体薄膜を介して容量形成用電極を形成することにより容量素子を形成した請求項１記載の圧電薄膜振動子。

【請求項３】　上記圧電体薄膜が、酸化亜鉛、窒化アルミニウム、チタン酸鉛、チタン酸ジルコン酸鉛、チタン酸バリウム、ニオブ酸リチウム及びタンタル酸リチウムからなる群から選ばれた少なくとも１つの圧電材料を含んで形成された請求項１又は２記載の圧電薄膜振動子。

【請求項４】　上記第１誘電体薄膜が、酸化マグネシウム、酸化アルミニウム、酸化シリコン、窒化シリコン、酸化窒化シリコン、酸化タンタル、酸化チタン及び酸化ニオブからなる群から選ばれた少なくとも１つの誘電体を含んで形成された請求項１～３のうちのいずれか１つに記載の圧電薄膜振動子。

【請求項５】　上記第１誘電体薄膜が上記圧電体薄膜上面のほぼ全面に形成されている請求項１～４のうちのいずれか１つに記載の圧電薄膜振動子。

【請求項６】　請求項１～５のうちのいずれか１つに記載の圧電薄膜振動子が基板上に絶縁膜を介して設けられ、かつ上記基板において該圧電薄膜振動子の直下に開口部が形成されている圧電薄膜振動子。

【請求項７】　上記圧電薄膜振動子においてさらに、上記開口部の外側に位置する基板上に上記絶縁膜を介して第１と第２のパッド電極が形成され、上記第１のパッド電極が上記１対の励振用電極のうちの下部に位置する電極に接続され、かつ上記第２のパッド電極が上記１対の励振用電極のうちの上部に位置する電極又は上記容量形成用電極に接続された請求項６記載の圧電薄膜振動子。

【請求項８】　上記第２のパッド電極と上記１対の励振用電極のうちの上部に位置する電極又は上記容量形成用電極との間が、導電性架橋で接続された請求項７記載の圧電薄膜振動子。

【請求項９】　一対の励振用電極と圧電体薄膜とを備えた圧電薄膜振動子において、
上記一対の励振用電極のうちの少なくとも一方の電極上に、誘電体薄膜を介して容量形成用電極を形成することにより容量素子を形成した圧電薄膜振動子。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、圧電体薄膜を用いた圧電体薄膜素子、特に数百ＭＨｚからＧＨｚ帯の周波数域で動作するフィルタ、共振器に用いることができる圧電体薄膜素子に関する。

【０００２】

【従来の技術】近年、移動体通信の発達に伴い、比較的高い周波数で使用されるフィルタや共振器の需要が拡大している。なかでも圧電体を用いた振動子は、小型軽量化が可能であることから、圧電体の体積振動を利用した振動子や圧電体の表面を伝搬する表面弾性波を用いたもの等、種々のタイプのものの高周波化が検討されている。圧電体の体積振動（バルク振動）を利用した振動子は、圧電体がその厚さに比例した波長で共振することを利用して所定の周波数で振動させるものであるため、高い周波数で振動させるためには、圧電体の膜厚を薄くする必要がある。例えば、このタイプの素子を、移動体通信等の通信機器に適用しようとすると、これらの機器に用いられる周波数は数百ＭＨｚからＧＨｚ帯におよぶ高い周波数であるために、圧電体の厚さを１～２ミクロン以下にすることが必要となる。このタイプの振動子としては、水晶発振器があるが、この水晶発振器は、圧電体として用いる単結晶水晶を研磨して作製されるので、薄板化に一定の限界があり、上述の高い周波数帯で使用することはできない。

【０００３】従って、最近では、種々の薄膜形成法により膜厚１～２ミクロン程度の厚さに形成した圧電体薄膜を用いて、移動体通信に用いることができる体積振動を利用した圧電薄膜素子が検討されている。すなわち、該圧電薄膜素子では、薄膜形成法により膜厚１～２ミクロン程度の厚さに形成された圧電体薄膜の両面に、薄膜電極が形成され、この電極に交流電圧を印加することにより、圧電体薄膜の厚さに対応した周波数で共振させている。この構成では、振動エネルギーのロスを防ぐために通常は共振部の下の基板を除去し、共振部を浮かせた浮き構造が取られる。この浮き構造の製造手法としては、基板としてヒ化ガリウム（ＧａＡｓ）を用いて上部構造を形成し、基板裏面からの硫酸等のエッチング液により基板をエッチング除去して素子を形成する例が良く知られている。また、基板としてシリコン（Ｓｉ）を用いて上部構造を形成し、基板裏面からの水酸化カリウム等のアルカリによるＳｉの異方性エッチングにより圧電膜下の基板を除去して形成することも可能である。

【０００４】従来、報告されている素子の一例を示せば、例えば、特開平６－３５０１５４号公報に開示された素子では、基板上に絶縁膜を介して、下側薄膜電極、圧電膜、上側薄膜電極を形成し、基板裏面からの基板を除去することで、振動部となる部分の下の基板を除去し、浮き構造を実現している。

【０００５】

【発明が解決しようとする課題】しかしながら、圧電体薄膜の体積振動を利用した素子の場合、その動作周波数となる共振周波数は、上述のように圧電体の厚さに対応して一義的に決定されるので、特定の周波数で振動させ

るためには、極めて高精度な膜厚制御が必要とされる。高周波化するために膜厚を薄くするとますます膜厚の制御は困難なものとなる。そのために実際には、膜厚を制御するだけでは、所定の共振周波数に設定することは困難であり、何らかの方法を用いて周波数を調整する必要があるが、現状では簡便で効果的な周波数調整方法がないために、調整工程に関わるコストが高くなり素子価格を安価にできないという問題点があった。また、表面弾性波を利用した振動子においても、その共振周波数は電極のパターンによって決定されるため、精度よく電極パターンを形成する必要があるが、電極パターンを精度よく形成するだけで、所定の共振周波数に設定することが困難であり、何らかの周波数調整方法を用いる必要がある。従って、表面弾性波を利用した振動子においても、同様の問題点を有していた。

【０００６】従って、本発明の目的は、短い時間でかつ簡便に周波数調整することができる構造を有し、安価に製造できる圧電薄膜素子を提供することにある。

【０００７】

【課題を解決するための手段】本発明は、以上の従来例の問題点を解決するためになされたものである。すなわち、本発明に係る圧電薄膜振動子は、一対の励振用電極の間に圧電体薄膜を備えた圧電薄膜振動子において、上記一対の励振用電極の間にさらに第１誘電体薄膜を設け、上記圧電体薄膜の厚さと上記第１誘電体薄膜の厚さとを合わせた厚さに対応した周波数で共振させたことを特徴とする。

【０００８】また、上記圧電薄膜振動子において、上記一対の励振用電極のうち上部に位置する励振用電極上に第２誘電体薄膜を介して容量形成用電極を形成することにより容量素子を形成することが好ましい。これによって、容量素子の静電容量値を変化させることにより、共振周波数を変化させることができる。

【０００９】さらに、上記圧電薄膜振動子においては、安定した圧電特性を得るために、上記圧電体薄膜が、酸化亜鉛、窒化アルミニウム、チタン酸鉛、チタン酸ジルコン酸鉛、チタン酸バリウム、ニオブ酸リチウム及びタンタル酸リチウムからなる群から選ばれた少なくとも１つの圧電材料を含んで形成されることが好ましい。

【００１０】またさらに、上記圧電薄膜振動子においては、上記第１誘電体薄膜が、それぞれ膜厚制御性に優れた、酸化マグネシウム、酸化アルミニウム、酸化シリコン、窒化シリコン、酸化窒化シリコン、酸化タンタル、酸化チタン及び酸化ニオブからなる群から選ばれた少なくとも１つの誘電体を含んで形成されることが好ましい。

【００１１】また、上記圧電薄膜振動子においては、上記第１誘電体薄膜に圧電体薄膜をエッチングするときのマスクとしての機能をもたせるために、上記第１誘電体薄膜が上記圧電体薄膜上面のほぼ全面に形成されていることが好ましい。

【００１２】また、本発明では、上記圧電薄膜振動子を基板上に絶縁膜を介して設け、上記基板において該圧電薄膜振動子の直下に開口部を形成するように構成してもよい。

【００１３】さらに、上記圧電薄膜振動子においてさらに、上記開口部の外側に位置する基板上に上記絶縁膜を介して第１と第２のパッド電極を形成し、上記第１のパッド電極を上記１対の励振用電極のうちの下部に位置する電極に接続し、かつ上記第２のパッド電極を上記１対の励振用電極のうちの上部に位置する電極又は上記容量形成用電極に接続するようにしてもよい。

【００１４】また、上記圧電薄膜振動子では、上記第２のパッド電極と上記１対の励振用電極のうちの上部に位置する電極又は上記容量形成用電極との間を、導電性架橋で接続することが好ましい。

【００１５】また、本発明に係る別の態様の圧電薄膜振動子は、一対の励振用電極と圧電体薄膜とを備えた圧電薄膜振動子において、上記一対の励振用電極のうちの少なくとも一方の電極上に、誘電体薄膜を介して容量形成用電極を形成することにより容量素子を形成したことを特徴とし、この容量素子を用いて共振周波数を調整することができる。

【００１６】

【発明の実施の形態】以下に、本発明に係る実施の形態について説明する。

実施の形態１．実施の形態１の圧電薄膜素子は、開口部２１を有する基板上に絶縁膜２を介して振動部が形成された素子であって、その振動部が、図１に示すように、下部電極１６と上部電極１５との間に圧電体薄膜１３及び誘電体薄膜１４の２種類の層を備え、上部電極１５（励振用電極）と下部電極１６（励振用電極）とによって励振される振動部が圧電体薄膜１３及び誘電体薄膜１４の合計の厚さに対応した周波数で共振させることを特徴とする。尚、実施の形態１において、振動部は開口部２１の直上に位置する絶縁膜２（自由に振動することができる部分）上に設けられる。

【００１７】以上のように構成された実施の形態１の圧電薄膜素子において、音波は圧電体薄膜１３と誘電体薄膜１４との複合層内を厚さ方向に伝搬して、その厚み方向で共振を起こす。従って、実施の形態１の圧電薄膜素子の共振周波数は、主として圧電体薄膜１３の圧電定数と、圧電体薄膜１３の厚さと誘電体薄膜１４の厚さとの合計の厚さとによって決定される。尚、本実施の形態１において、圧電体薄膜１３の材料としては酸化亜鉛、窒化アルミニウム、チタン酸鉛或いはチタン酸ジルコン酸鉛に代表される鉛系圧電材料、チタン酸バリウムおよびその変成材料、ニオブ酸リチウム、タンタル酸リチウム等のアルカリ金属とニオブ、タンタルとの複合酸化物などを用いることが好ましく、これらの材料で形成するこ

とにより比較的安定した圧電特性を得ることができる。
【００１８】上述の圧電材料を用いて圧電体薄膜１３を形成することにより、圧電体薄膜１３の圧電定数は比較的精度よく管理できるので、圧電体薄膜１３の厚さと誘電体薄膜１４の厚さとの合計の厚さを一定の範囲内に精度よく管理することにより、共振周波数の精度を向上が期待できる。従って、実施の形態１の圧電薄膜素子において、誘電体薄膜１４は圧電体薄膜１３に比較して精度よく膜厚を形成できることが好ましい。
【００１９】また、本実施の形態１の圧電薄膜素子において、音波を圧電体薄膜１３と誘電体薄膜１４との複合層内を厚さ方向に伝搬させるので、誘電体薄膜１４は圧電体薄膜１３に比較的近い音響インピーダンスを有する材料で形成することが好ましい。しかしながら、音響インピーダンスに関しては、密度が著しくことならなければ良く、化合物系の膜、特に酸化物系の膜で有れば、インピーダンスの面からは殆ど問題なく用いることができる。結晶構造についても、圧電体薄膜１３の結晶構造と誘電体薄膜１４の結晶構造とが同一であったり、類似である必要はない。さらに、誘電体薄膜１４は高い絶縁性が要求されることはいうまでもない。尚、本明細書において、単に誘電体薄膜又は誘電体膜というときは、圧電性を持たない絶縁性材料よりなる膜を意味するものとする。
【００２０】誘電体薄膜１４の誘電率は、圧電体薄膜と電気的に並列接続にする場合には、特に制限は無いが、本実施の形態１のように、直列に接続する場合には、回路として電圧印加能力が十分にあり、圧電体薄膜１３に十分な電圧が印加できればよい。しかしながら、圧電体薄膜１３の容量に比較して誘電体薄膜１４の持つ容量が同等以下程度となるように設定することが好ましい。以上説明したような要件を満足し、誘電体薄膜１４に適した材料としては、酸化マグネシウム、酸化アルミニウム、酸化シリコン、窒化シリコン、酸化窒化シリコン、酸化タンタル、酸化チタン、酸化ニオブなどを挙げることができる。
【００２１】以上説明したように、実施の形態１の圧電薄膜振動子は、誘電体薄膜１４として膜厚制御性のよい誘電体を用いることにより、圧電体薄膜１３と誘電体薄膜１４とを合わせた膜厚を精度よく形成できるので、より所定の周波数に近い周波数で共振させることができる。
【００２２】次に、実施の形態１の圧電薄膜素子の作製手順について説明する。最初に、例えば、主表面が（１００）面となるように形成されたＧａＡｓからなる基板１上に、反応ガスとしてシランと酸素を用い、成膜温度３００℃としたプラズマＣＶＤ（Ｃｈｅｍｉｃａｌ ｖａｐｏｕｒ ｄｅｐｏｓｉｔｉｏｎ）法により膜厚約２００ｎｍの二酸化シリコン膜（絶縁膜２）を形成する。次に、絶縁膜２上に、３０ｎｍの厚さのチタン膜と、７０ｎｍの厚さ白金膜とからなる２層構造の下部電極を蒸着法により形成する。この下部電極は後述するようにパターンニングされて、下部電極１６、パッド電極１７，１８となる。次に、下部電極上に、鉛２０ｍｏｌ％過剰のチタン酸鉛よりなるターゲットを用いて、アルゴンガスと酸素ガスとの混合ガス中、成膜圧力１Ｐａ、基板温度６００℃にてスパッタ法により、チタン酸鉛からなる圧電体薄膜を０．９５μｍの厚さに形成する。
【００２３】次に、その圧電体薄膜上に、上記と同様なプラズマＣＶＤにより二酸化シリコン薄膜からなる誘電体薄膜を０．０５μｍとなるように（すなわち、圧電体薄膜１３との合計の厚さが１μｍとなるように）形成する。次に、二酸化シリコン膜からなる誘電体薄膜上に下部電極と同様の２層構造からなる電極を形成した後、リフトオフ法を用いて所定の形状の上部電極１５を形成する。ここで、上部電極１５は、図示はしていないが、チタン膜と白金膜との２層構造を有する。その後、二酸化シリコン膜からなる誘電体薄膜を１％フッ酸水溶液によりレジストを用いたウェットエッチングで、上部電極１５と同形状になるようにパターンニングを行うことにより、誘電体薄膜１４を形成する。更に、圧電体薄膜をレジストマスクにより、７０℃の塩酸と硝酸との混合溶液により不要部分をエッチング除去し、２００ミクロン×１００ミクロンの方形の圧電体薄膜１５を形成する。
【００２４】次に、下部電極をイオンミリング法によりパターンニングを行い、２５０ミクロン×１５０ミクロンの方形の下部電極１６を形成する。このとき、同時に圧電体薄膜１３の外側の基板１上に上部電極１５と接続するためのパッド電極１７を下部電極１６から離れて形成し、下部電極１６と接続電極１９で接続されたパッド電極１８を形成する。尚、パッド電極１７はチタン膜３ａと白金膜４ａとからなり、パッド電極１８はチタン膜３ｂと白金膜４ｂとからなる。そして、上部電極１５とパッド電極１７とを架橋２０を形成することにより接続する。ここで、架橋２０は、上部電極１５上の架橋２０との接続部分とパッド電極１７上の架橋２０との接続部分を除いてレジストを形成した後、金メッキ膜を約２０μｍ形成し、その後、レジストを除去することにより形成される。
【００２５】最後に、基板を約１００μｍの厚さまで研磨し、薄板化した後、基板裏面からエッチングすることにより開口部２１を形成する。以上のようにして実施の形態１の圧電薄膜素子を作製することができる。以上のように作製した圧電薄膜素子において、圧電体薄膜１３の厚さが０．９５μｍであり、誘電体薄膜１４の厚さが０．０４７μｍである素子の共振周波数は、１．７４ＧＨｚであった。さらに、同様なプロセスにより、ウェハの異なる素子１０個を作製して評価したところ、各素子の共振周波数は１．７１～１．７８ＧＨｚの範囲であり、共振周波数の標準偏差は±０．０３ＧＨｚであっ

た。

【００２６】また、本発明者らは、比較例として図２に示す素子を作製して、上述の実施の形態１に基づいて作製した素子と比較した。図２の比較例の圧電薄膜素子は、図１の実施の形態１の圧電薄膜素子から誘電体薄膜１４を除い構成した以外は、実施の形態１と同様に構成される。尚、図２において図１と同様のものには同様の符号を付して示している。この比較例の圧電薄膜素子を１０個作製して、それぞれの共振周波数を測定したところ、１．６０（最小）～１．８１（最大）ＧＨｚの範囲で共振が観測され、共振周波数のばらつきを表す標準偏差は、±０．０８ＧＨｚであった。尚、圧電体薄膜１３の膜厚は、目標値１μｍに対して、０．９６～１．０５μｍの範囲でばらついていた。以上の結果から、実施の形態１に示したように誘電体薄膜１４を形成することにより、共振周波数のばらつきを小さくできることがわかる。

【００２７】実施の形態２．次に本発明に係る実施の形態２の圧電薄膜素子について説明する。この実施の形態２の圧電薄膜素子は、図３に示すように、実施の形態１の圧電薄膜素子においてさらに、上部電極１５上に誘電体薄膜２２を介して容量形成用電極２３を形成したことを特徴とし、それ以外は実施の形態１と同様に構成される。すなわち、実施の形態２の圧電薄膜素子は、実施の形態１と同様にして上部電極１５まで形成した後、上部電極１５上にプラズマＣＶＤにより膜厚０．１μｍの二酸化シリコン薄膜２２（誘電体薄膜２２）を形成し、その二酸化シリコン膜２２上に、１００μｍ×１００μｍ角の容量形成用電極２３を蒸着及びリフトオフ法を用いて形成した。その後は実施の形態１と同様に、圧電体薄膜の不要部分のエッチング除去、下部電極用薄膜のパターンニング、下部薄膜電極と下部電極パッド及び架橋を形成し、さらに、開口部２１を形成して圧電体薄膜素子を形成した。

【００２８】以上のように作製することにより、圧電体薄膜１３上に、圧電振動子と直列に、上部電極１５、二酸化シリコン膜２２及び容量形成用電極２３によって構成される静電容量が形成され、その容量値は４ｐＦであった。また、上述のようにして作製された圧電薄膜素子の共振周波数は１．６ＧＨｚであった。

【００２９】以上のように作製された圧電薄膜振動子では、圧電体薄膜１３上に形成された、上部電極１５、二酸化シリコン膜２２及び容量形成用電極２３によって形成される静電容量は周波数調整用のコンデンサ（容量素子）として用いることができる。尚、上述の例では、二酸化シリコン膜２２を用いて周波数調整用のコンデンサを形成したが、本発明はこれに限らず、他の誘電体薄膜を用いてもよい。

【００３０】すなわち、本実施の形態２の圧電薄膜素子は、圧電薄膜素子において、圧電振動子と直列に形成された静電容量を変化させることにより、共振周波数を数％の範囲内で変化させることができることを利用したものであり、かつ周波数調整用コンデンサを素子と一体で形成したものである。この周波数調整用コンデンサの静電容量は誘電体薄膜２２上の容量形成用電極２３をレーザ等を用いて一部除去することにより、変化させることが可能である。尚、誘電体薄膜２２は、誘電体薄膜１４と同様な材料を適用することができる。

【００３１】また、誘電体薄膜２２上の容量形成用電極２３を部分的に削除することにより周波数調整用コンデンサの静電容量を変化させようとすると、結果的に容量形成用電極２３の重量を変化させることになり、その重量変化によっても共振周波数を変化させることになる。従って、実施の形態２では、容量形成用電極２３の質量と周波数調整用コンデンサの付加容量とを変化させることによってて周波数を調整していることになる。ここで、実施の形態２の構成では、容量形成用電極２３を削ることにより、容量形成用電極２３の質量を減少させかつ周波数調整用コンデンサの付加容量を減少させ、それぞれの変化はいずれも一方向に周波数を変化（重畳して変化させる）させるので、この工程により周波数調整幅を拡大することができ、周波数調整の作業時間の短縮することができる。

【００３２】実施の形態３．以下、本発明に係る実施の形態３の圧電薄膜素子について説明する。実施の形態３の圧電薄膜素子は、実施の形態１における上部電極１５と実質的に同じ大きさに形成された誘電体薄膜１４に代えて、圧電体薄膜１３と実質的に同じ大きさに形成された誘電体薄膜２４を用いた以外は、実施の形態１と同様に構成される。すなわち、実施の形態３の厚保手銭薄膜素子では、実施の形態１と同様にして、１００μｍ×１００μｍ角の薄膜電極１５まで形成した後、二酸化シリコン膜を最終的に残留させる圧電薄膜１３と同形状の２００μｍ×１００μｍになるように、１％フッ酸水溶液にてライトエッチングしてパターンニングする。その後、圧電薄膜をレジストマスクにより、７０℃の塩酸と硝酸との混合溶液により不要部分をエッチング除去し、２００ミクロン×１００ミクロンの形状とする。この時、二酸化シリコン膜２４（誘電体薄膜２４）の存在により、圧電薄膜をエッチングする時のサイドエッチング量が低減され、従来約１０μｍ程度あったサイドエッチング量が３μｍ程度に低減され、圧電薄膜のパターンニング精度を向上させることができる。

【００３３】この後、実施の形態１と同様にして下部電極１６のパターンニング、下部薄膜電極と下部電極パッドとの接続等を行い、さらに架橋２０を形成した後、開口部２１を形成して図４に示す圧電薄膜素子を形成した。この図４の圧電薄膜素子を異なる１０ウェハを用いて各ウエハから合計１０個の圧電薄膜素子を作製しそれぞれ測定した結果、平均共振周波数は１．５５ＧＨｚ

で、ばらつきは±０．０４ＧＨｚであった。すなわち、以上のように構成しても比較例に比べ製造ばらつきを低減できる圧電薄膜素子を提供できる。

【００３４】以上の実施の形態３の圧電薄膜素子では、圧電薄膜上に所定の大きさに誘電体薄膜２４を形成した後、誘電体薄膜２４をマスクとして用いて圧電体薄膜１３を形成している。このようにすると、誘電体薄膜２４は圧電体薄膜に対して、一般にレジストよりも優れた密着性を持っているので、圧電体薄膜１３のサイドエッチング量を低減することができ、圧電体薄膜を精度よく形成できる。すなわち、圧電体薄膜を塩酸、硝酸等の強酸により、湿式でエッチングする場合には、レジストのみをエッチングマスクとして用いると、密着性の不完全さからマスク下の圧電薄膜がエッチングされる現象が見られるが、本実施の形態３では、圧電薄膜に対して密着性のよい誘電体薄膜を用いて圧電薄膜をエッチングしているので、圧電薄膜のサイドエッチング量を低減することができる。尚、本実施の形態３では二酸化シリコンを用いて誘電体薄膜２４を形成したが、本発明はこれに限定されるものではなく、他の誘電体材料を用いることもできる。

【００３５】実施の形態４．本発明に係る実施の形態４の圧電薄膜素子は、表面弾性波を利用した素子であって、基板１００上に絶縁膜１０２を介して圧電膜１１３が形成され、その圧電膜１１３上に櫛形電極１１６ａ，１１６ｂが形成されてなる。ここで、特に実施の形態４の圧電薄膜素子では、櫛形電極１１６ａ，１１６ｂ上にそれぞれ誘電体薄膜１２４ａ，１２４ｂを介して容量形成用電極１１５ａ，１１５ｂが形成され、その電極１１５ａ，１１５ｂがそれぞれ、架橋１２０ａ，１２０ｂを介してパッド電極１１７，１１８に接続されていることを特徴とする。尚、パッド電極１１７，１１８はそれぞれ、チタン膜１０３ａ，１０３ｂと白金１０４ａ，１０４ｂとからなる。すなわち、本実施の形態４の圧電薄膜素子では、櫛形電極１１６ａ，１１６ｂがそれぞれ、誘電体薄膜１２４ａ，１２４ｂを用いて構成された周波数調整用のコンデンサを介してパッド電極１１７，１１８に接続されている。これによって、電極１１５ａ，１１５ｂの面積を例えばレーザを用いて削る等して変化させることにより、共振周波数を調整することができる。

【００３６】以上説明した各実施の形態において、振動部の電極とパッド電極との間を架橋により接続している。これにより、接続部分における断線を防止でき、かつ振動部の自由な振動を確保でき振動特性を良好にできる。しかしながら、本発明はこれに限られるものではなく、通常の表面配線を用いて接続してもよい。また、架橋自体を構成する材料は良導電性で有ればよいが、簡便には通常のマイクロ波ＩＣ用プロセス等で用いられている金メッキで形成することができる。

【００３７】

【発明の効果】以上詳細に説明したように、本発明に係る圧電薄膜振動子は、上記圧電体薄膜に加え上記第１誘電体薄膜を設け、上記圧電体薄膜の厚さと上記第１誘電体薄膜の厚さとを合わせた厚さに対応した周波数で共振させているので、該膜厚を精度よく設定でき、共振周波数のばらつきを小さくできる。これによって、周波数の調整範囲を小さくできるので、短い時間で周波数調整することができ、安価に製造できる。

【００３８】また、上記圧電薄膜振動子において、上記励振用電極上に第２誘電体薄膜を介して容量形成用電極を形成されてなる容量素子を形成して、該容量素子の静電容量値を変化させることにより、共振周波数を調整することができる。

【００３９】さらに、上記圧電薄膜振動子において、上記圧電体薄膜を、酸化亜鉛、窒化アルミニウム、チタン酸鉛、チタン酸ジルコン酸鉛、チタン酸バリウム、ニオブ酸リチウム及びタンタル酸リチウムからなる群から選ばれた少なくとも１つの圧電材料を含んで形成することにより、安定した圧電特性を得ることができ、共振周波数のばらつきをさらに小さくできる。これによって、周波数の調整範囲をさらに小さくできるので、より短い時間で周波数調整することができ、さらに安価に製造できる。

【００４０】またさらに、上記圧電薄膜振動子において、上記第１誘電体薄膜を、それぞれ膜厚制御性に優れた、酸化マグネシウム、酸化アルミニウム、酸化シリコン、窒化シリコン、酸化窒化シリコン、酸化タンタル、酸化チタン及び酸化ニオブからなる群から選ばれた少なくとも１つの誘電体を含んで形成することにより、上記圧電体薄膜と上記第１誘電体薄膜の合計の膜厚を精度よく管理でき、共振周波数のばらつきを極めて小さくできる。

【００４１】また、上記圧電薄膜振動子においては、上記第１誘電体薄膜を上記圧電体薄膜上面のほぼ全面に形成することにより、上記第１誘電体薄膜に圧電体薄膜をエッチングするときのマスクとしての機能をもたせることができ、圧電体薄膜の形状を精度よく形成することができる。

【００４２】また、本発明では、上記圧電薄膜振動子を基板上に絶縁膜を介して設けることにより、容易に製造することができる。

【００４３】さらに、上記圧電薄膜振動子においてさらに、上記第１と第２のパッド電極を形成し、上記第１のパッド電極を上記１対の励振用電極のうちの下部に位置する電極に接続し、かつ上記第２のパッド電極を上記１対の励振用電極のうちの上部に位置する電極又は上記容量形成用電極に接続することにより、外部回路との接続を容易にできる。

【００４４】また、上記圧電薄膜振動子では、上記第２のパッド電極と上記１対の励振用電極のうちの上部に位

置する電極又は上記容量形成用電極との間を、導電性架橋で接続することにより、振動部分の自由な振動を確保でき、安定した損失の小さい共振が可能となる。

【００４５】また、本発明に係る別の態様の圧電薄膜振動子は、上記一対の励振用電極のうちの少なくとも一方の電極上に、誘電体薄膜を介して容量形成用電極を形成することにより容量素子を形成しているので、この容量素子を用いて共振周波数を容易に調整することができる。

【図面の簡単な説明】

【図１】　本発明に係る実施の形態１の圧電薄膜振動子の構成を示す図であって、（ａ）は平面図であり、（ｂ）は（ａ）のＡ－Ａ’線についての断面図であり、（ｃ）は（ａ）のＢ－Ｂ’線についての断面図である。

【図２】　比較例の圧電薄膜振動子の構成を示す図であって、（ａ）は平面図であり、（ｂ）は（ａ）のＣ－Ｃ’線についての断面図であり、（ｃ）は（ａ）のＤ－Ｄ’線についての断面図である。

【図３】　本発明に係る実施の形態２の圧電薄膜振動子の構成を示す図であって、（ａ）は平面図であり、（ｂ）は（ａ）のＣ－Ｃ’線についての断面図であり、（ｃ）は（ａ）のＤ－Ｄ’線についての断面図である。

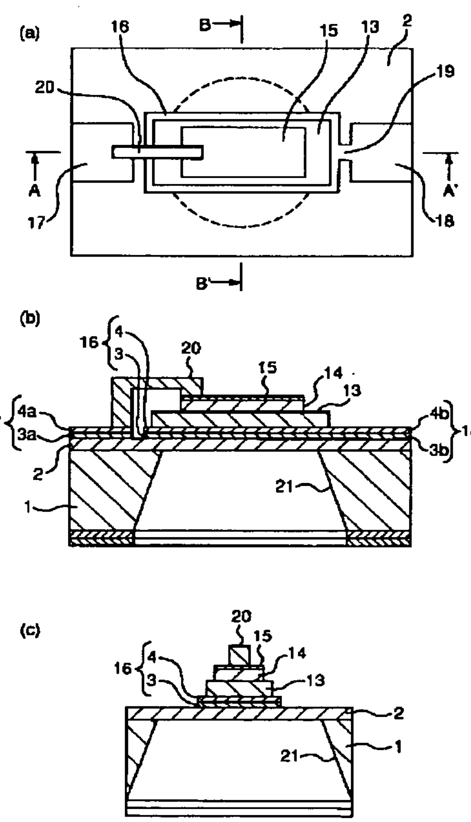
【図４】　本発明に係る実施の形態３の圧電薄膜振動子の構成を示す図であって、（ａ）は平面図であり、（ｂ）は（ａ）のＧ－Ｇ’線についての断面図であり、（ｃ）は（ａ）のＨ－Ｈ’線についての断面図である。

【図５】　本発明に係る実施の形態４の圧電薄膜振動子の構成を示す図であって、（ａ）は平面図であり、（ｂ）は（ａ）のＩ－Ｉ’線についての断面図である。

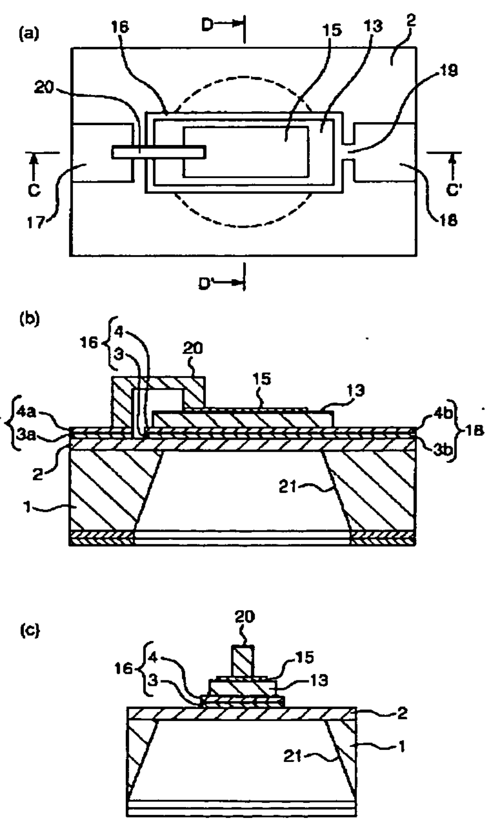
【符号の説明】

１，１００　基板、２，１０２　絶縁膜、３，３ａ，３ｂ　チタン膜、４，４ａ，４ｂ　白金膜、１３，１１３　圧電体薄膜、１４，２２，２４，１２４ａ，１２４ｂ　誘電体薄膜、１５　上部電極、１６　下部電極、１７，１８，１１７，１１８　パッド電極、１９　接続電極、２０，１２０ａ，１２０ｂ　導電性架橋、２１　開口部、２３，１１５ａ，１１５ｂ　容量形成用電極、１１６ａ，１１６ｂ　櫛形電極。

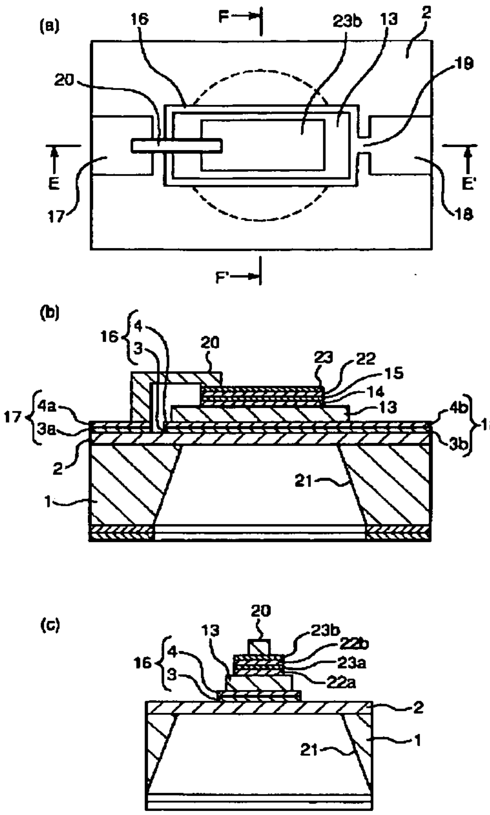
【図１】



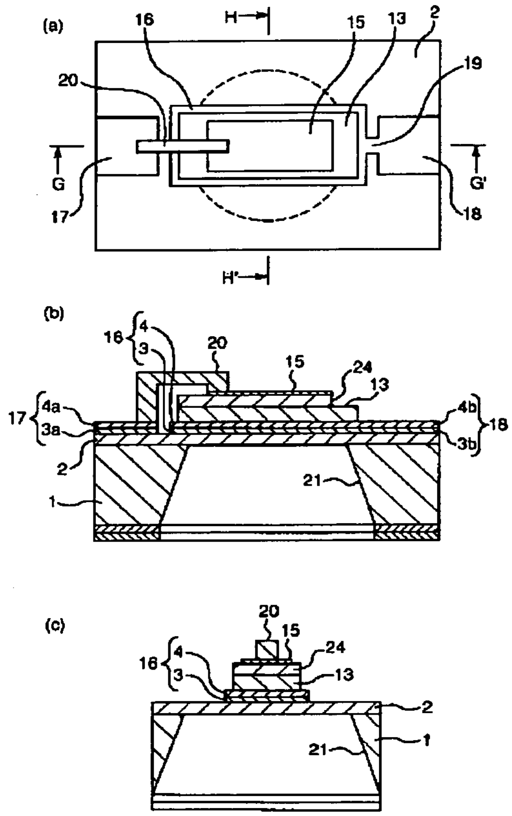
【図２】



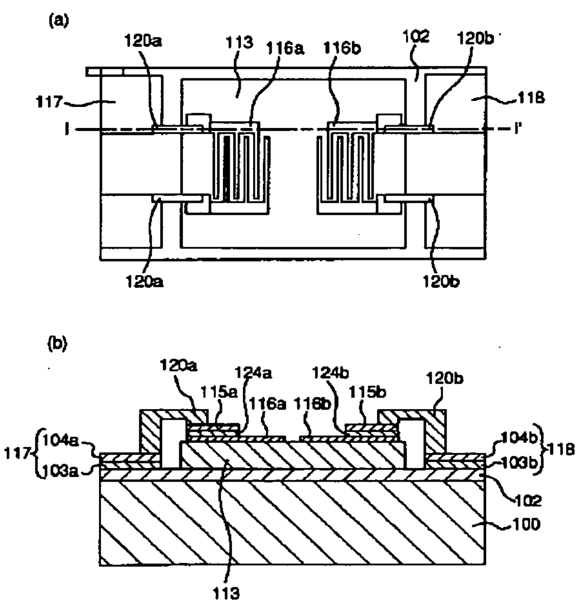
【図３】


(a)
16
F
23b
13
2
20
19
E
E'
17
18
F'
(b)
16
4
3
20
23
22
15
14
13
17
4a
3a
4b
3b
18
2
21
1
(c)
20
13
23b
22b
23a
22a
16
4
3
2
21
1

【図４】


(a)
16
H
15
13
2
20
19
G
G'
17
18
H'
(b)
16
4
3
20
15
24
13
17
4a
3a
4b
3b
18
2
21
1
(c)
20
15
24
13
16
4
3
2
21
1

【図５】


(a)
120a
113
116a
116b
102
120b
117
118
I
I'
120a
120b
(b)
120a
124a
124b
120b
115a
116a
116b
115b
117
104a
103a
104b
103b
118
102
100
113

フロントページの続き

(72)発明者　内川　英興
東京都千代田区丸の内二丁目２番３号　三
菱電機株式会社内

Bibliography

---

(19) [Publication country] Japan Patent Office (JP)
(12) [Kind of official gazette] Open patent official report (A)
(11) [Publication No.] JP, 11-284480, A
(43) [Date of Publication] October 15, Heisei 11 (1999)
(54) [Title of the Invention] Piezo-electric thin film vibrator
(51) [International Patent Classification (6th Edition)]
H03H 9/17
[FI]
H03H 9/17 F
[Request for Examination] Un-asking.
[The number of claims] 9
[Mode of Application] OL
[Number of Pages] 9
(21) [Application number] Japanese Patent Application No. 10-81085
(22) [Filing date] March 27, Heisei 10 (1998)
(71) [Applicant]
[Identification Number] 000006013
[Name] Mitsubishi Electric Corp.
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo
(72) [Inventor(s)]
[Name] Yamada **
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]
[Name] Maeda ******
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(72) [Inventor(s)]
[Name] Umemura Toshio
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi

Electric Corp.
(72) [Inventor(s)]
[Name] Uchikawa Hidefusa
[Address] 2-2-3, Marunouchi, Chiyoda-ku, Tokyo Inside of Mitsubishi Electric Corp.
(74) [Attorney]
[Patent Attorney]
[Name] Aoyama ** (besides one person)

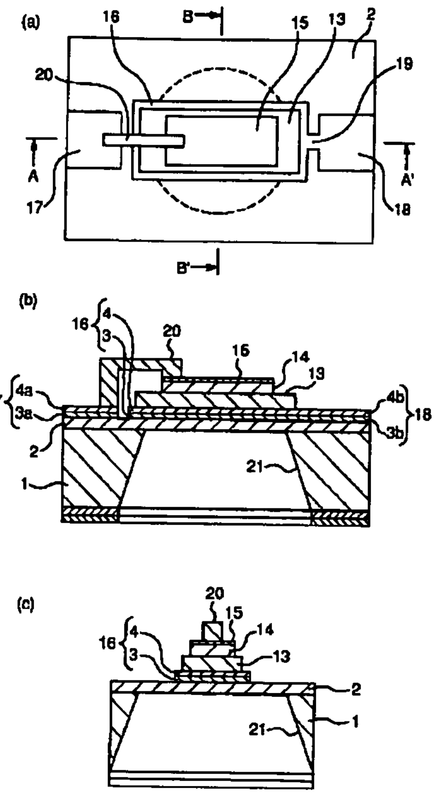
[Translation done.]

Epitome

---

(57) [Abstract]
[Technical problem] It has the structure which is short time amount and can carry out frequency regulation simple, and the piezo-electric thin film which can be manufactured cheaply is offered.
[Means for Solution] The 1st dielectric thin film was further prepared between the electrodes for excitation of a pair, and it was made to resonate in the piezo-electric thin film vibrator equipped with the piezo electric crystal thin film between the electrodes for excitation of a pair on the frequency corresponding to the thickness which doubled the thickness of a piezo electric crystal thin film, and the thickness of the 1st dielectric thin film.

[Translation done.]



[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3. In the drawings, any words are not translated.

CLAIMS

[Claim(s)]

[Claim 1] Piezo-electric thin film vibrator characterized by making it resonate on the frequency corresponding to the thickness which prepared the 1st dielectric thin film further between the electrodes for excitation of the above-mentioned pair, and doubled the thickness of the above-mentioned piezo electric crystal thin film, and the thickness of

the above-mentioned 1st dielectric thin film in the piezo-electric thin film vibrator equipped with the piezo electric crystal thin film between the electrodes for excitation of a pair.
[Claim 2] Piezo-electric thin film vibrator according to claim 1 which formed the capacitative element by forming the electrode for capacity formation through the 2nd dielectric thin film in the above-mentioned piezo-electric thin film vibrator on the electrode for excitation located in the upper part among the electrodes for excitation of the above-mentioned pair.
[Claim 3] Piezo-electric thin film vibrator according to claim 1 or 2 formed including at least one piezoelectric material chosen from the group which the above-mentioned piezo electric crystal thin film becomes from a zinc oxide, alumimium nitride, lead titanate, titanic-acid lead zirconate, barium titanate, lithium niobate, and lithium tantalate.
[Claim 4] Piezo-electric thin film vibrator of any one publication among claims 1-3 formed including at least one dielectric chosen from the group which the above-mentioned 1st dielectric thin film becomes from a magnesium oxide, an aluminum oxide, silicon oxide, silicon nitride, oxidization silicon nitride, tantalum oxide, titanium oxide, and niobium oxide.
[Claim 5] Piezo-electric thin film vibrator of any one publication of the above-mentioned 1st dielectric thin film among claims 1-4 on the above-mentioned top face of a piezo electric crystal thin film currently mostly formed in the whole surface.
[Claim 6] Piezo-electric thin film vibrator with which the piezo-electric thin film vibrator of any one publication among claims 1-5 is prepared through an insulator layer on a substrate, and opening is formed directly under this piezo-electric thin film vibrator in the above-mentioned substrate.
[Claim 7] In the above-mentioned piezo-electric thin film vibrator, the 1st and 2nd pad electrode is further formed through the above-mentioned insulator layer on the substrate located in the outside of the above-mentioned opening. Piezo-electric thin film vibrator according to claim 6 by which the pad electrode of the above 1st was connected to the electrode located in the lower part of the one above-mentioned pair of electrodes for excitation, and the pad electrode of the above 2nd was connected to the electrode or the above-mentioned electrode for capacity formation located in the upper part of the one above-mentioned pair of electrodes for excitation.
[Claim 8] Piezo-electric thin film vibrator according to claim 7 to which between the electrodes or the above-mentioned electrodes for

capacity formation which are located in the upper part of the pad electrode of the above 2nd and the one above-mentioned pair of electrodes for excitation was connected by conductive bridge formation.
[Claim 9] Piezo-electric thin film vibrator which formed the capacitative element in the piezo-electric thin film vibrator equipped with the electrode for excitation and piezo electric crystal thin film of a pair by forming the electrode for capacity formation through a dielectric thin film on one [at least] electrode of the electrodes for excitation of the above-mentioned pair.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the piezo electric crystal thin film which used the piezo electric crystal thin film especially the filter which operates from hundreds of MHz in the frequency region of a GHz band, and the piezo electric crystal thin film which can be used for a resonator.
[0002]
[Description of the Prior Art] In recent years, the need of the filter used on a comparatively high frequency or a resonator is expanded with development of mobile communications. Since the formation of small lightweight is possible for the vibrator which used the piezo electric crystal especially, RF-ization of the thing of various types, such as a thing using the surface acoustic waves which spread the front face of the vibrator using volume vibration of a piezo electric crystal or a piezo electric crystal, is considered. Since a piezo electric crystal is what is vibrated on a predetermined frequency using resonating on the

wavelength proportional to the thickness, in order to vibrate the vibrator using volume vibration (bulk vibration) of a piezo electric crystal on a high frequency, it needs to make thickness of a piezo electric crystal thin. For example, when it is going to apply this type of component to communication equipment, such as mobile communications, since the frequency used for these devices is a high frequency which attains to a GHz band from hundreds of MHz, it is necessary to make thickness of a piezo electric crystal into 1-2 microns or less. As this type of vibrator, although there is a crystal oscillator, since single crystal Xtal used as a piezo electric crystal is ground and it is produced, this crystal oscillator has a fixed limitation in sheet metalization, and cannot be used with an above-mentioned high frequency band.
[0003] Therefore, by recently, the piezo-electric thin film using volume vibration which can be used for mobile communications is examined using the piezo electric crystal thin film formed in the thickness of about 1-2 microns of thickness by the various thin film forming methods. That is, a thin film electrode is formed in both sides of the piezo electric crystal thin film formed in the thickness of about 1-2 microns of thickness by the thin film forming method, and it is made to resonate on the frequency corresponding to the thickness of a piezo electric crystal thin film by impressing alternating voltage to this electrode by this piezo-electric thin film. With this configuration, in order to prevent the loss of vibrational energy, the substrate under the resonance section is usually removed, and the floating construction which floated the resonance section is taken. The example which forms a superstructure as the manufacture technique of this floating construction, using gallium arsenide (GaAs) as a substrate, carries out etching removal of the substrate with etching reagents, such as a sulfuric acid from a substrate rear face, and forms a component is known well. Moreover, it is also possible to form a superstructure, using silicon (Si) as a substrate, and for the anisotropic etching of Si by alkali, such as a potassium hydroxide from a substrate rear face, to remove the substrate under a piezoelectric film, and to form.
[0004] If an example of a component reported is shown conventionally, with the component indicated by JP,6-350154,A, the bottom thin film electrode, the piezoelectric film, and the top thin film electrode were formed through the insulator layer on the substrate, by removing the substrate from a substrate rear face, the substrate under the part used as the oscillating section would be removed, and floating construction will be realized, for example.
[0005]

[Problem(s) to be Solved by the Invention] However, since the resonance frequency which turns into the clock frequency in the case of the component using volume vibration of a piezo electric crystal thin film is uniquely determined as mentioned above corresponding to the thickness of a piezo electric crystal, in order to make it vibrate on a specific frequency, very highly precise thickness control is needed. If thickness is made thin in order to RF-ize, control of thickness will become difficult increasingly. Therefore, in the present condition, although it is difficult to set it as predetermined resonance frequency and the frequency needed to be adjusted only by controlling thickness in fact using a certain approach, since there was no simple and effective frequency regulation approach, there was a trouble that the cost in connection with an adjustment process became high, and could not make a component price cheap. Moreover, also in the vibrator using surface acoustic waves, although it is necessary to form an electrode pattern with a sufficient precision since the resonance frequency is determined by the pattern of an electrode, an electrode pattern is only formed with a sufficient precision, it is difficult to set it as predetermined resonance frequency, and it needs to use a certain frequency regulation approach. Therefore, also in the vibrator using surface acoustic waves, it had the same trouble.

[0006] Therefore, the purpose of this invention has the structure which is short time amount and can carry out frequency regulation simple, and is to offer the piezo-electric thin film which can be manufactured cheaply.

[0007]

[Means for Solving the Problem] This invention is made in order to solve the trouble of the above conventional example. That is, the piezo-electric thin film vibrator concerning this invention is characterized by making it resonate on the frequency corresponding to the thickness which prepared the 1st dielectric thin film further between the electrodes for excitation of the above-mentioned pair, and doubled the thickness of the above-mentioned piezo electric crystal thin film, and the thickness of the above-mentioned 1st dielectric thin film in the piezo-electric thin film vibrator equipped with the piezo electric crystal thin film between the electrodes for excitation of a pair.

[0008] Moreover, in the above-mentioned piezo-electric thin film vibrator, it is desirable to form a capacitative element by forming the electrode for capacity formation through the 2nd dielectric thin film on the electrode for excitation located in the upper part among the electrodes for excitation of the above-mentioned pair. By this,

resonance frequency can be changed by changing the electrostatic-capacity value of a capacitative element.

[0009] Furthermore, in the above-mentioned piezo-electric thin film vibrator, in order to acquire the stable piezo-electric property, it is desirable that the above-mentioned piezo electric crystal thin film is formed including at least one piezoelectric material chosen from the group which consists of a zinc oxide, alumimium nitride, lead titanate, titanic-acid lead zirconate, barium titanate, lithium niobate, and lithium tantalate.

[0010] Furthermore, in the above-mentioned piezo-electric thin film vibrator, it is desirable that the above-mentioned 1st dielectric thin film is formed including at least one dielectric chosen from the group which was excellent in the thickness controllability, respectively, and which it becomes from a magnesium oxide, an aluminum oxide, silicon oxide, silicon nitride, oxidization silicon nitride, tantalum oxide, titanium oxide, and niobium oxide.

[0011] Moreover, in the above-mentioned piezo-electric thin film trembler, in order to give the function as a mask when etching a piezo electric crystal thin film into the above-mentioned 1st dielectric thin film, the thing on the above-mentioned top face of a piezo electric crystal thin film for which the above-mentioned 1st dielectric thin film is mostly formed in the whole surface is desirable.

[0012] Moreover, the above-mentioned piezo-electric thin film vibrator may be prepared through an insulator layer on a substrate, and you may constitute from this invention so that opening may be formed directly under this piezo-electric thin film vibrator in the above-mentioned substrate.

[0013] Furthermore, in the above-mentioned piezo-electric thin film vibrator, the 1st and 2nd pad electrode is further formed through the above-mentioned insulator layer on the substrate located in the outside of the above-mentioned opening. The pad electrode of the above 1st is connected to the electrode located in the lower part of the one above-mentioned pair of electrodes for excitation, and you may make it connect the pad electrode of the above 2nd to the electrode or the above-mentioned electrode for capacity formation located in the upper part of the one above-mentioned pair of electrodes for excitation.

[0014] Moreover, it is desirable to connect between the electrodes or the above-mentioned electrodes for capacity formation which are located in the upper part of the pad electrode of the above 2nd and the one above-mentioned pair of electrodes for excitation according to conductive bridge formation in the above-mentioned piezo-electric thin

film vibrator.
[0015] Moreover, in the piezo-electric thin film vibrator equipped with the electrode for excitation and piezo electric crystal thin film of a pair, by forming the electrode for capacity formation through a dielectric thin film on one [at least] electrode of the electrodes for excitation of the above-mentioned pair, another piezo-electric thin film vibrator of a mode concerning this invention can be characterized by forming a capacitative element, and can adjust resonance frequency using this capacitative element.
[0016]
[Embodiment of the Invention] Below, the gestalt of operation concerning this invention is explained.
The piezo-electric thin film of the gestalt 1 of gestalt 1.
implementation of operation Are the component by which the oscillating section was formed through the insulator layer 2 on the substrate which has opening 21, and as shown in drawing 1 , the oscillating section It has two kinds of layers, the piezo electric crystal thin film 13 and the dielectric thin film 14, between the lower electrode 16 and the up electrode 15. The oscillating section excited with the up electrode 15 (electrode for excitation) and the lower electrode 16 (electrode for excitation) is characterized by making it resonate on the frequency corresponding to the thickness of the sum total of the piezo electric crystal thin film 13 and the dielectric thin film 14. In addition, in the gestalt 1 of operation, the oscillating section is prepared on the insulator layer 2 (part which can vibrate freely) located in right above [of opening 21].
[0017] In the piezo-electric thin film of the gestalt 1 of the operation constituted as mentioned above, an acoustic wave spreads the inside of the compound layer of the piezo electric crystal thin film 13 and the dielectric thin film 14 in the thickness direction, and causes resonance in the thickness direction. Therefore, the resonance frequency of the piezo-electric thin film of the gestalt 1 of operation is mainly determined by the thickness of the sum total of the piezoelectric constant of the piezo electric crystal thin film 13, and the thickness of the piezo electric crystal thin film 13 and the thickness of the dielectric thin film 14. In addition, in the gestalt 1 of this operation, it is desirable to use the multiple oxide of alkali metal, such as lead system piezoelectric material represented by a zinc oxide, alumimium nitride, lead titanate, or titanic-acid lead zirconate as an ingredient of the piezo electric crystal thin film 13, barium titanate and its conversion ingredient, lithium niobate, and lithium tantalate, and a

niobium and a tantalum etc., and the piezo-electric property stabilized comparatively can be acquired by forming with these ingredients.

[0018] Since the piezoelectric constant of the piezo electric crystal thin film 13 can be managed with a comparatively sufficient precision by forming the piezo electric crystal thin film 13 using an above-mentioned piezoelectric material, improvement can expect the precision of resonance frequency by managing the thickness of the sum total of the thickness of the piezo electric crystal thin film 13, and the thickness of the dielectric thin film 14 with a sufficient precision within fixed limits. Therefore, as for the dielectric thin film 14, in the piezo-electric thin film of the gestalt 1 of operation, it is desirable that thickness can be formed with a sufficient precision as compared with the piezo electric crystal thin film 13.

[0019] Moreover, in the piezo-electric thin film of the gestalt 1 of this operation, since the inside of the compound layer of the piezo electric crystal thin film 13 and the dielectric thin film 14 is made to spread an acoustic wave in the thickness direction, as for the dielectric thin film 14, it is desirable to form with the ingredient which has an acoustic impedance comparatively near the piezo electric crystal thin film 13. However, if it is by the film of a compound system, especially the film of an oxide system about an acoustic impedance that what is necessary is for there just to be nothing if consistencies are things remarkably, from the field of an impedance, it can use almost satisfactory. About the crystal structure, the crystal structure of the piezo electric crystal thin film 13 and the crystal structure of the dielectric thin film 14 do not need to be similar in being the same. Furthermore, it cannot be overemphasized that insulation with the expensive dielectric thin film 14 is required. In addition, in this specification, when only calling it a dielectric thin film or a dielectric film, the film which consists of an insulating ingredient without piezoelectric shall be meant.

[0020] What is necessary is for there to be especially no limit, in using the dielectric constant of the dielectric thin film 14 as a piezo electric crystal thin film electrically at parallel connection, but for there to be electrical-potential-difference impression capacity of enough as a circuit, and just to be able to impress sufficient electrical potential difference for the piezo electric crystal thin film 13 like the gestalt 1 of this operation, when connecting with a serial. However, it is desirable to set up so that the capacity which the dielectric thin film 14 has as compared with the capacity of the piezo electric crystal thin film 13 may serve as below equivalent extent.

Requirements which were explained above can be satisfied and a magnesium oxide, an aluminum oxide, silicon oxide, silicon nitride, oxidization silicon nitride, tantalum oxide, titanium oxide, niobium oxide, etc. can be mentioned as an ingredient suitable for the dielectric thin film 14.
[0021] As explained above, since the piezo-electric thin film vibrator of the gestalt 1 of operation can form the thickness which set the piezo electric crystal thin film 13 and the dielectric thin film 14 by using the good dielectric of a thickness controllability as a dielectric thin film 14 with a sufficient precision, it can be resonated on the frequency near a more nearly predetermined frequency.
[0022] Next, the production procedure of the piezo-electric thin film of the gestalt 1 of operation is explained. the plasma CVD (Chemical vapour deposition) which first used a silane and oxygen as reactant gas for example, on the substrate 1 which consists of GaAs formed so that the main front face might turn into a field (100), and was made into the membrane formation temperature of 300 degrees C -- the diacid-ized silicon film (insulator layer 2) of about 200nm of thickness is formed by law. Next, the lower electrode of the two-layer structure which consists of titanium film with a thickness of 30nm and 70nm thickness platinum film is formed with vacuum deposition on an insulator layer 2. Pattern NINGU of this lower electrode is carried out so that it may mention later, and it turns into the lower electrode 16 and the pad electrodes 17 and 18. Next, the piezo electric crystal thin film which consists of lead titanate is formed in the thickness of 0.95 micrometers by the spatter among the mixed gas of argon gas and oxygen gas using the target which consists of 20 mol lead titanate with superfluous % of lead on a lower electrode at the membrane formation pressure of 1Pa, and the substrate temperature of 600 degrees C.
[0023] Next, the dielectric thin film which consists of a diacid-ized silicon thin film by the same plasma CVD as the above on the piezo electric crystal thin film is formed so that it may be set to 0.05 micrometers (that is, the thickness of the sum total with the piezo electric crystal thin film 13 is set to 1 micrometer like). Next, after forming a lower electrode and the electrode which consists of same two-layer structure on the dielectric thin film which consists of diacid-ized silicon film, the up electrode 15 of a predetermined configuration is formed using the lift-off method. Here, although the up electrode 15 has not carried out illustration, it has the two-layer structure of the titanium film and the platinum film. Then, the dielectric thin film 14 is formed by performing pattern NINGU so that it may become the shape of the up electrode 15 and isomorphism by the wet etching using a resist

with a fluoric acid water solution 1% about the dielectric thin film which consists of diacid-ized silicon film. Furthermore, a piezo electric crystal thin film is carried out with a resist mask, etching removal of the garbage is carried out with the mixed solution of a 70-degree C hydrochloric acid and a nitric acid, and the piezo electric crystal thin film 15 of a 200 micron x100 micron rectangle is formed.
[0024] Next, pattern NINGU is performed for a lower electrode by the ion milling method, and the lower electrode 16 of a 250 micron x150 micron rectangle is formed. At this time, the pad electrode 17 for connecting with the up electrode 15 is left and formed from the lower electrode 16 on the substrate 1 of the outside of the piezo electric crystal thin film 13 at coincidence, and the pad electrode 18 connected with the lower electrode 16 and the connection electrode 19 is formed. In addition, the pad electrode 17 consists of titanium film 3a and platinum film 4a, and the pad electrode 18 consists of titanium film 3b and platinum film 4b. And the up electrode 15 and the pad electrode 17 are connected by forming bridge formation 20. Here, after forming a resist except for the connection part of a connection part with the bridge formation 20 on the up electrode 15, and the bridge formation 20 on the pad electrode 17, bridge formation 20 forms about 20 micrometers of gold plate film, and is formed by removing a resist after that.
[0025] Finally, after grinding and sheet-metal-izing a substrate to the thickness of about 100 micrometers, opening 21 is formed by etching from a substrate rear face. The piezo-electric thin film of the gestalt 1 of operation is producible as mentioned above. In the piezo-electric thin film produced as mentioned above, the resonance frequency of the component whose thickness of the dielectric thin film 14 the thickness of the piezo electric crystal thin film 13 is 0.95 micrometers, and is 0.047 micrometers was 1.74GHz. Furthermore, when the same process produced and estimated ten components from which a wafer differs, the range of the resonance frequency of each component was 1.71-1.78GHz, and the standard deviation of resonance frequency was **0.03GHz.
[0026] Moreover, this invention persons compared with the component which produced the component shown in drawing 2 as an example of a comparison, and was produced based on the gestalt 1 of above-mentioned operation. The piezo-electric thin film of the example of a comparison of drawing 2 consists of piezo-electric thin films of the gestalt 1 of operation of drawing 1 like the gestalt 1 of operation except having carried out the **** configuration of the dielectric thin film 14. In addition, in drawing 2 , the same sign is attached and shown in the same thing as drawing 1 . When ten piezo-electric thin films of this example

of a comparison were produced and each resonance frequency was measured, the standard deviation which resonance is observed in the range of 1.60(min) -1.81(max) GHz, and expresses dispersion in resonance frequency was **0.08GHz. In addition, the thickness of the piezo electric crystal thin film 13 varied in 0.96-1.05 micrometers to the desired value of 1 micrometer. By forming the dielectric thin film 14 from the above result, as shown in the gestalt 1 of operation shows that dispersion in resonance frequency can be made small.

[0027] The piezo-electric thin film of the gestalt 2 of operation concerning gestalt 2. of operation, next this invention is explained. As shown in drawing 3 , in the piezo-electric thin film of the gestalt 1 of operation, further, the piezo-electric thin film of the gestalt 2 of this operation is characterized by forming the electrode 23 for capacity formation through the dielectric thin film 22 on the up electrode 15, and is constituted like the gestalt 1 of operation except it. That is, after even the up electrode 15 formed like the gestalt 1 of operation, the piezo-electric thin film of the gestalt 2 of operation formed the diacid-ized silicon thin film 22 (dielectric thin film 22) of 0.1 micrometers of thickness by plasma CVD on the up electrode 15, and on the diacid-ized silicon film 22, the electrode 23 for capacity formation of a 100 micrometerx100-micrometer angle was used for it, and it formed vacuum evaporationo and the lift-off method. After that, like the gestalt 1 of operation, etching removal of the garbage of a piezo electric crystal thin film, pattern NINGU of the thin film for lower electrodes, a lower thin film electrode, a lower electrode pad, and bridge formation were formed, further, opening 21 was formed and the piezo electric crystal thin film was formed.

[0028] By producing as mentioned above, the electrostatic capacity constituted by a piezoelectric transducer and the serial with the up electrode 15, the diacid-ized silicon film 22, and the electrode 23 for capacity formation was formed on the piezo electric crystal thin film 13, and the capacity value was 4pF. Moreover, the resonance frequency of the piezo-electric thin film produced as mentioned above was 1.6GHz.

[0029] In the piezo-electric thin film vibrator produced as mentioned above, the electrostatic capacity formed with the up electrode 15, the diacid-ized silicon film 22, and the electrode 23 for capacity formation which were formed on the piezo electric crystal thin film 13 can be used as a capacitor for frequency regulation (capacitative element). In addition, in an above-mentioned example, although the capacitor for frequency regulation was formed using the diacid-ized silicon film 22, this invention may use not only this but other dielectric thin films.

[0030] That is, in a piezo-electric thin film, by changing the electrostatic capacity formed in the piezoelectric transducer and the serial, the piezo-electric thin film of the gestalt 2 of this operation uses that resonance frequency can be changed by several% of within the limits, and forms the capacitor for frequency regulation by the component and one. As for the electrostatic capacity of this capacitor for frequency regulation, by removing the electrode 23 for capacity formation on the dielectric thin film 22 in part using laser etc., it is possible to make it change. In addition, the dielectric thin film 22 can apply the same ingredient as the dielectric thin film 14.

[0031] Moreover, when it is going to change the electrostatic capacity of the capacitor for frequency regulation by deleting partially the electrode 23 for capacity formation on the dielectric thin film 22, the weight of the electrode 23 for capacity formation is made to change as a result, and resonance frequency is made to change also with the weight change. Therefore, with the gestalt 2 of operation, the frequency will be adjusted by changing the mass of the electrode 23 for capacity formation, and the addition capacity of the capacitor for frequency regulation. since the mass of the electrode 23 for capacity formation is decreased, and the addition capacity of the capacitor for frequency regulation is decreased and each of each change changes a frequency to an one direction here by shaving the electrode 23 for capacity formation with the configuration of the gestalt 2 of operation (it is made to superimpose and change) -- this process -- frequency regulation width of face -- being expandable -- the working hours of frequency regulation -- it can be shortened .

[0032] The piezo-electric thin film of the gestalt 3 of operation concerning this invention is explained below gestalt 3. of operation. The piezo-electric thin film of the gestalt 3 of operation is replaced with the up electrode 15 in the gestalt 1 of operation, and the dielectric thin film 14 substantially formed in the same magnitude, and is constituted like the gestalt 1 of operation except having used the piezo electric crystal thin film 13 and the dielectric thin film 24 substantially formed in the same magnitude. That is, in the Atsu **** thin film of the gestalt 3 of operation, like the gestalt 1 of operation, after even the thin film electrode 15 of a 100 micrometerx100-micrometer angle forms, light etching is carried out in a fluoric acid water solution 1%, and pattern NINGU is carried out so that it may be set to 200micrometerx100micrometer of the shape of the piezo-electric thin film 13 which makes the diacid-ized silicon film remain finally, and isomorphism. Then, a piezo-electric thin film is carried out with a

resist mask, etching removal of the garbage is carried out with the mixed solution of a 70-degree C hydrochloric acid and a nitric acid, and it considers as a 200 micron x100 micron configuration. At this time, by existence of the diacid-ized silicon film 24 (dielectric thin film 24), the amount of side etching when etching a piezo-electric thin film is reduced, the amount of side etching whose about 10 micrometers were conventionally is reduced by about 3 micrometers, and the pattern NINGU precision of a piezo-electric thin film can be raised.

[0033] Then, after making pattern NINGU of the lower electrode 16, connection between a lower thin film electrode and a lower electrode pad, etc. like the gestalt 1 of operation and forming bridge formation 20 further, the piezo-electric thin film which forms opening 21 and is shown in drawing 4 was formed. As a result of producing a total of ten piezo-electric thin films and measuring from each wafer using ten wafers which are different in the piezo-electric thin film of this drawing 4 , respectively, average resonance frequency was 1.55GHz and dispersion was **0.04GHz. That is, even if constituted as mentioned above, the piezo-electric thin film which can reduce manufacture dispersion compared with the example of a comparison can be offered.

[0034] In the piezo-electric thin film of the gestalt 3 of the above operation, on a piezo-electric thin film, after forming the dielectric thin film 24 in predetermined magnitude, the piezo electric crystal thin film 13 is formed, using the dielectric thin film 24 as a mask. If it does in this way, since the dielectric thin film 24 generally has the adhesion superior to a resist to the piezo electric crystal thin film, the amount of side etching of the piezo electric crystal thin film 13 can be reduced, and a piezo electric crystal thin film can be formed with a sufficient precision. That is, if it uses only a resist as an etching mask in etching a piezo electric crystal thin film with wet with strong acid, such as a hydrochloric acid and a nitric acid, the phenomenon in which the piezo-electric thin film under a mask is etched from the imperfection of adhesion will be seen, but with the gestalt 3 of this operation, since the piezo-electric thin film is etched using the good dielectric thin film of adhesion to a piezo-electric thin film, the amount of side etching of a piezo-electric thin film can be reduced. In addition, although the dielectric thin film 24 was formed using diacid-ized silicon with the gestalt 3 of this operation, this invention is not limited to this and can also use other dielectric materials.

[0035] The piezo-electric thin film of the gestalt 4 of operation concerning gestalt 4. this invention of operation is a component using surface acoustic waves, a piezoelectric film 113 is formed through an

insulator layer 102 on a substrate 100, and it comes to form the Kushigata electrodes 116a and 116b on the piezoelectric film 113. It is characterized by forming the electrodes 115a and 115b for capacity formation through the dielectric thin films 124a and 124b, respectively on Kushigata electrode 116a and 116b, and connecting the electrodes 115a and 115b to the pad electrode 117,118 through bridge formation 120a and 120b by the piezo-electric thin film of the gestalt 4 of operation, here, respectively especially. In addition, the pad electrode 117,118 consists of titanium film 103a and 103b and platinum 104a and 104b, respectively. That is, in the piezo-electric thin film of the gestalt 4 of this operation, the Kushigata electrodes 116a and 116b are connected to the pad electrode 117,118 through the capacitor for frequency regulation constituted using the dielectric thin films 124a and 124b, respectively. Resonance frequency can be adjusted by carrying out deleting the area of Electrodes 115a and 115b using laser etc., and making it change with these.

[0036] In the gestalt of each operation explained above, between the electrode of the oscillating section and pad electrodes is connected according to bridge formation. By this, the open circuit in a connection part can be prevented, and a free vibration of the oscillating section can be secured, and an oscillation characteristic can be made good. However, this invention is not restricted to this and may be connected using the usual front wiring. Moreover, although there should just be an ingredient which constitutes the bridge formation itself by right conductivity, it can form by the gold plate used in the usual process for microwave IC etc. simple.

[0037]

[Effect of the Invention] As explained to the detail above, since the piezo-electric thin film vibrator concerning this invention is resonated on the frequency corresponding to the thickness which prepared the above-mentioned 1st dielectric thin film in addition to the above-mentioned piezo electric crystal thin film, and doubled the thickness of the above-mentioned piezo electric crystal thin film, and the thickness of the above-mentioned 1st dielectric thin film, it can set up this thickness with a sufficient precision, and can make dispersion in resonance frequency small. By this, since the adjustable range of a frequency can be made small, by short time amount, frequency regulation can be carried out and it can manufacture cheaply.

[0038] Moreover, in the above-mentioned piezo-electric thin film vibrator, resonance frequency can be adjusted by forming the capacitative element which has it come through the 2nd dielectric thin

film to form the electrode for capacity formation on the above-mentioned electrode for excitation, and changing the electrostatic-capacity value of this capacitative element.

[0039] Furthermore, in the above-mentioned piezo-electric thin film trembler, by forming the above-mentioned piezo electric crystal thin film including at least one piezoelectric material chosen from the group which consists of a zinc oxide, alumimium nitride, lead titanate, titanic-acid lead zirconate, barium titanate, lithium niobate, and lithium tantalate, the stable piezo-electric property can be acquired and dispersion in resonance frequency can be made still smaller. By this, since the adjustable range of a frequency can be made still smaller, by shorter time amount, frequency regulation can be carried out and it can manufacture still more cheaply.

[0040] Furthermore, in the above-mentioned piezo-electric thin film vibrator, by forming the above-mentioned 1st dielectric thin film including at least one dielectric chosen from the group which was excellent in the thickness controllability, respectively, and which consists of a magnesium oxide, an aluminum oxide, silicon oxide, silicon nitride, oxidization silicon nitride, tantalum oxide, titanium oxide, and niobium oxide, the thickness of the sum total of the above-mentioned piezo electric crystal thin film and the above-mentioned 1st dielectric thin film can be managed with a sufficient precision, and dispersion in resonance frequency can be made very small.

[0041] Moreover, in the above-mentioned piezo-electric thin film vibrator, the function as a mask when etching a piezo electric crystal thin film into the above-mentioned 1st dielectric thin film for the above-mentioned 1st dielectric thin film by [on the above-mentioned top face of a piezo electric crystal thin film] forming in the whole surface mostly can be given, and the configuration of a piezo electric crystal thin film can be formed with a sufficient precision.

[0042] Moreover, in this invention, it can manufacture easily by preparing the above-mentioned piezo-electric thin film vibrator through an insulator layer on a substrate.

[0043] Furthermore, connection with an external circuit makes easy further in the above-mentioned piezo-electric thin film vibrator by forming the above 1st and the 2nd pad electrode, and connecting the pad electrode of the above 1st to the electrode located in the lower part of the one above-mentioned pair of electrodes for excitation, and connecting the pad electrode of the above 2nd to the electrode or the above-mentioned electrode for capacity formation located in the upper part of the one above-mentioned pair of electrodes for excitation.

[0044] Moreover, in the above-mentioned piezo-electric thin film vibrator, by connecting between the electrodes or the above-mentioned electrodes for capacity formation which are located in the upper part of the pad electrode of the above 2nd, and the one above-mentioned pair of electrodes for excitation by conductive bridge formation, a free vibration of a vibrating part can be secured and small resonance of the stable loss is attained.
[0045] Moreover, since another piezo-electric thin film vibrator of a mode concerning this invention forms the capacitative element by forming the electrode for capacity formation through a dielectric thin film on one [at least] electrode of the electrodes for excitation of the above-mentioned pair, it can adjust resonance frequency easily using this capacitative element.

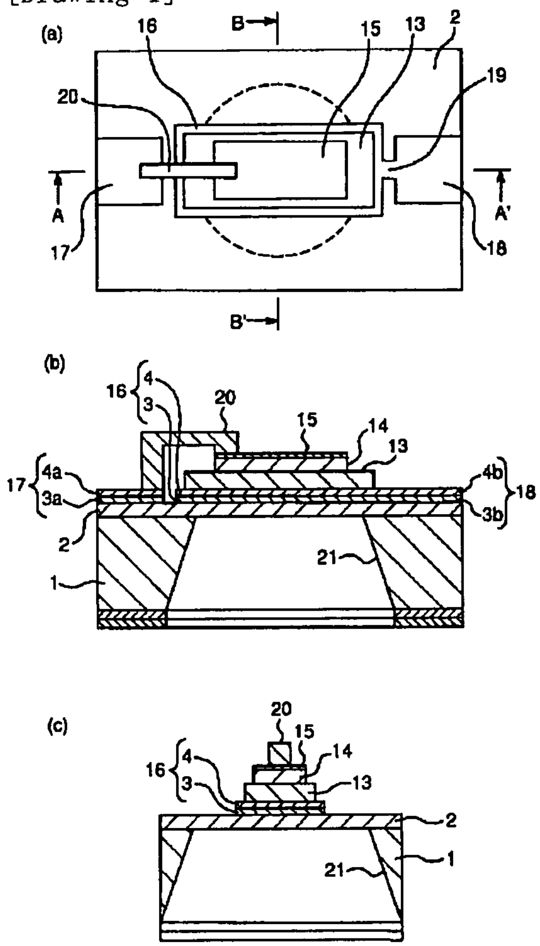
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (a) is a top view, it is drawing showing the configuration of the piezo-electric thin film vibrator of the gestalt 1 of operation concerning this invention, and (c) is [(b) is a sectional view about the A-A' line of (a), and] a sectional view about the B-B' line of (a).
[Drawing 2] (a) is a top view, it is drawing showing the configuration of the piezo-electric thin film vibrator of the example of a comparison, and (c) is [(b) is a sectional view about the C-C' line of (a), and] a sectional view about the D-D' line of (a).
[Drawing 3] (a) is a top view, it is drawing showing the configuration of the piezo-electric thin film vibrator of the gestalt 2 of operation concerning this invention, and (c) is [(b) is a sectional view about the C-C' line of (a), and] a sectional view about the D-D' line of (a).

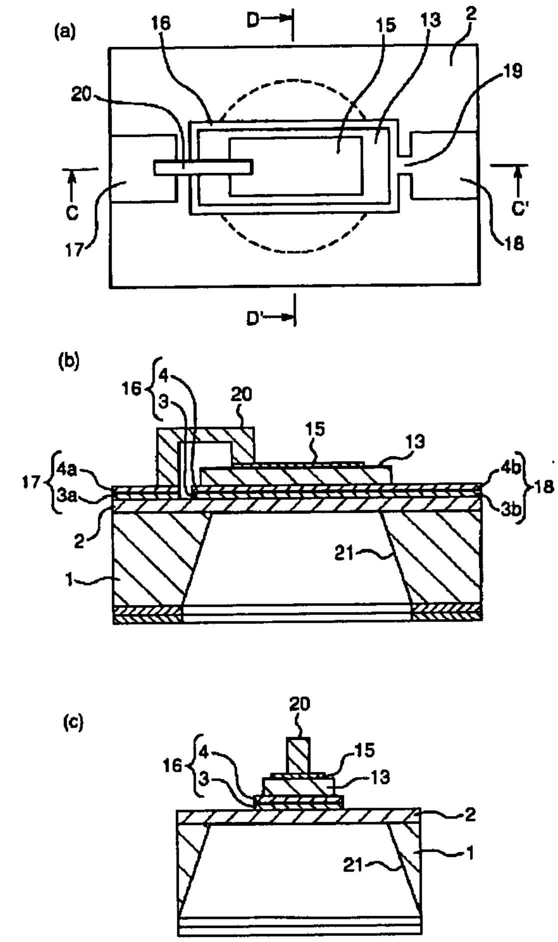
[Drawing 4] (a) is a top view, it is drawing showing the configuration of the piezo-electric thin film vibrator of the gestalt 3 of operation concerning this invention, and (c) is [(b) is a sectional view about the G-G' line of (a), and] a sectional view about the H-H' line of (a).
[Drawing 5] It is drawing showing the configuration of the piezo-electric thin film vibrator of the gestalt 4 of operation concerning this invention, and (a) is a top view and (b) is a sectional view about the I-I' line of (a).
[Description of Notations]
1,100 A substrate, 2,102 An insulator layer, 3, 3a, 3b Titanium film, 4, 4a, 4b The platinum film, 13,113 A piezo electric crystal thin film, 14, 22, 24,124a, 124b Dielectric thin film, 15 An up electrode, 16 17 A lower electrode, 18,117,118 A pad electrode, 19 Connection electrode, 20,120a, 120b Conductive bridge formation, 21 Opening, 23,115a, 115b The electrode for capacity formation, 116a, 116b Kushigata electrode.

DRAWINGS

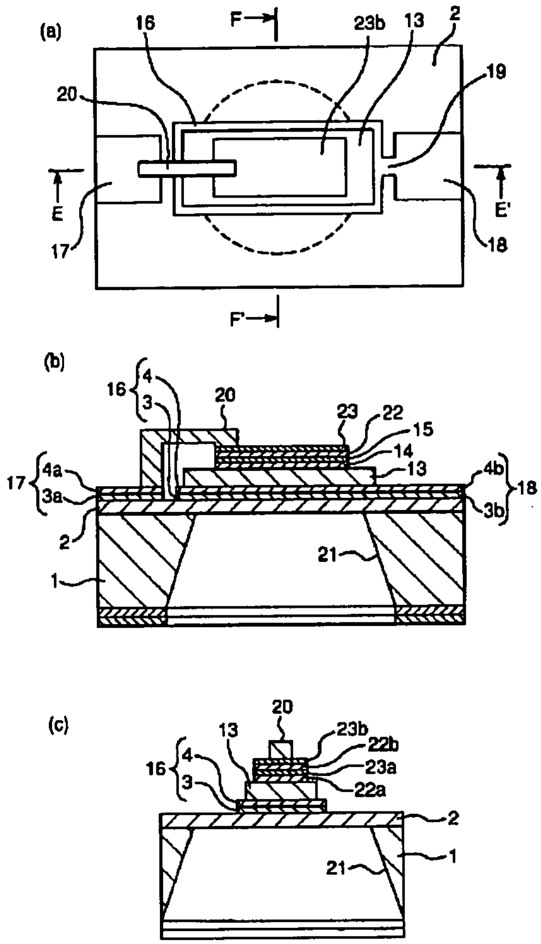
[Drawing 1]



[Drawing 2]

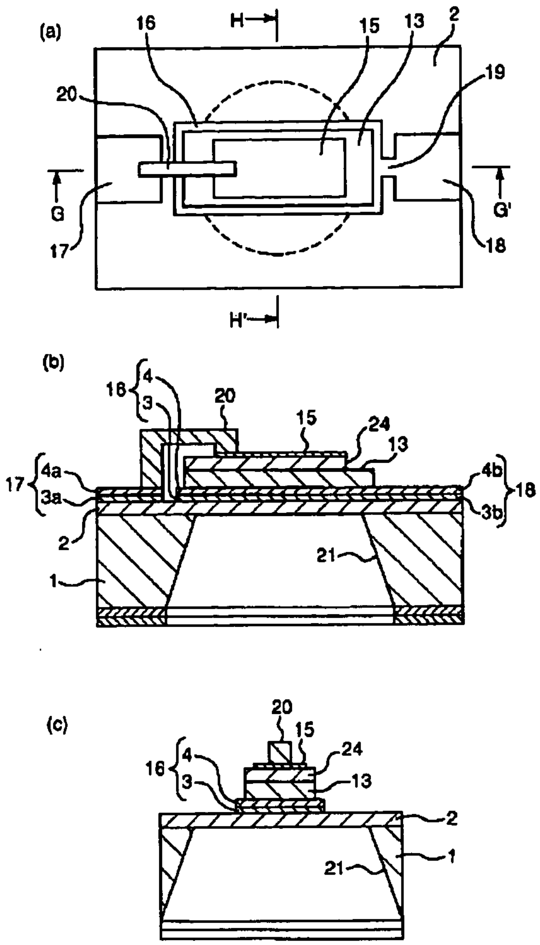

(a)
D
D'
C
C'
16
15
13
2
20
19
17
18
(b)
16
4
3
20
15
13
17
4a
3a
4b
3b
18
2
21
1
(c)
20
16
4
3
15
13
2
21
1

[Drawing 3]



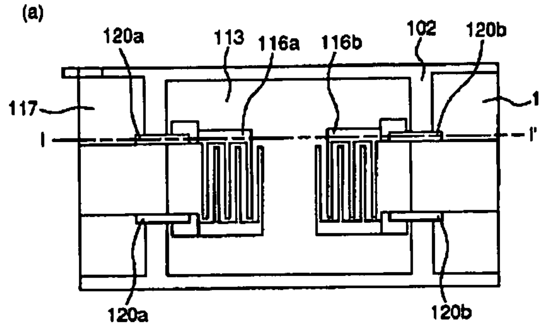
(a)
16
F
23b
13
2
20
19
E
E'
17
18
F'
(b)
16
4
3
20
23
22
15
14
13
17
4a
3a
4b
3b
18
2
21
1
(c)
20
13
23b
22b
23a
22a
16
4
3
2
21
1

[Drawing 4]

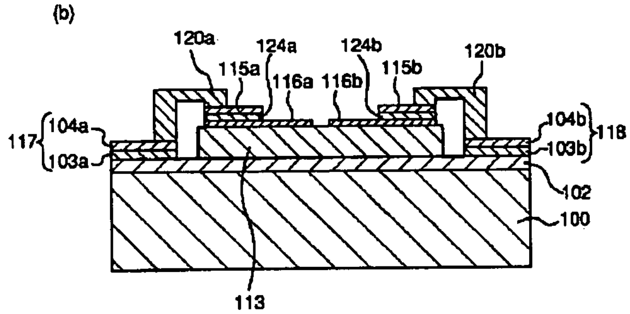

(a)
16
H
15
13
2
20
19
G
G'
17
18
H'
(b)
16
4
3
20
15
24
13
17
4a
3a
4b
3b
18
2
21
1
(c)
20
15
16
4
3
24
13
2
21
1

[Drawing 5]

(a)



(b)



[Translation done.]